Fuels, Engines, and Emissions

Stabilizing and Expanding HCCI Combustion with Spark Assist

Background

Gasoline engines are expected to dominate the U.S. passenger car market for at least the next decade. An improvement in the fuel efficiency of these engines would significantly reduce U.S. energy usage.

Homogeneous charge compression ignition (HCCI) in internal combustion engines is of considerable interest because of the potential reductions in nitrogen oxide (NO_X) emissions and fuel economy improvements resulting from unthrottled operation, faster heat release, and reduced heat transfer losses.

HCCI may not be sustainable under all conditions and loads in transportation applications. Thus, expanding the stable operating range and the ability to rapidly switch between HCCI and spark ignition combustion are the most important technical developments needed to achieve wide-spread HCCI utilization.

In addition, there are clearly many engine conditions under which HCCI is physically possible but marginally stable.

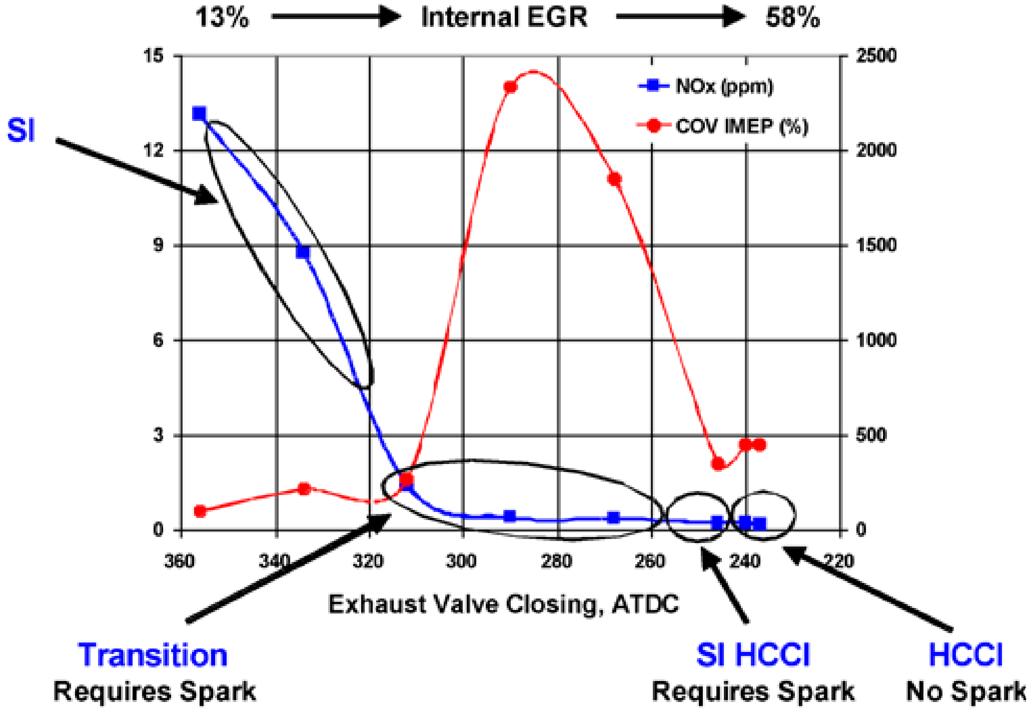

Figure 1. Stability and NO_X emissions during the transition from SI to HCCI combustion using internal EGR.

Because of this, the full potential cannot be realized until appropriate stabilizing strategies are developed to maximize the practical range of implementation.

Technology

The development of both combustion-mode switching and HCCI stabilization technologies requires that the fundamental nature of the transition between spark ignition (SI) and HCCI

Benefits

- Confirmed advantages of HCCI combustion as compared to unthrottled conventional operation.
- Enabled transitions to HCCI combustion and extended stable operating range.
- Identified and characterized existence of deterministic structure in cycle-to-cycle variations.
- Potential for development of control algorithms for expanding stable HCCI operation.

combustion be well understood, especially in the context of realistic engine conditions.

Oak Ridge National Laboratory (ORNL) researchers have mapped engine operation and stability for the transition between spark ignition and HCCI combustion modes on a single-cylinder engine. The instability appears to be low-dimensional. This suggests the possibility of developing on-line diagnostics and proactive control algorithms for expanding stable HCCI operation and improving transitions between conventional and HCCI modes.

Status

Commercial application of HCCI strategies will require advances over a broad range of technologies including combustion mode sensing (direct or virtual), combustion control, and mode transition control. ORNL is addressing these enabling technologies as a path to meeting DOE goals of improved emissions and efficiency. The results from of this activity are being shared with industry, universities, and other national laboratories. Examples include regular presentations to a multi-laboratory, multi-company working group on advanced engine combustion research and regular publications with the Society of Automotive Engineers and the Combustion Institute. ORNL also reports findings to industry stakeholders annually at both the Advanced Combustion and Emissions Program Merit Review.

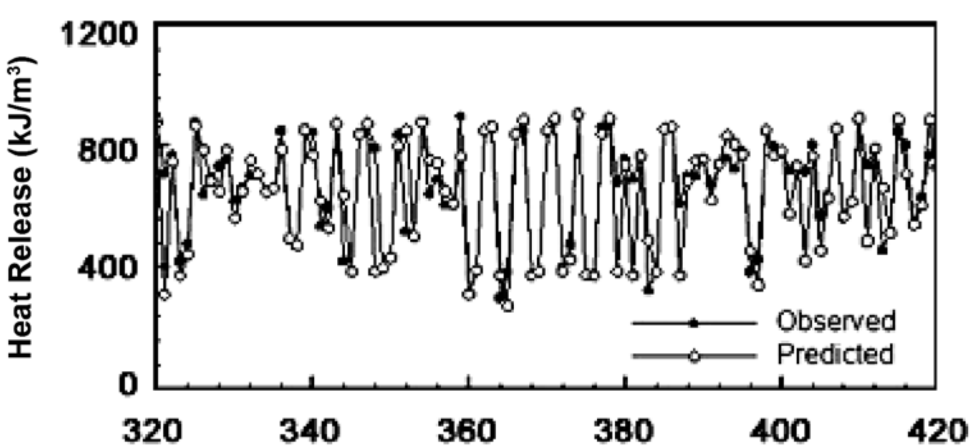

Figure 2. *Example of experimentally observed and predicted heat release time series for SI-HCCI transition.*

Contacts

Dr. Ronald L. Graves
ORNL Project Manager
Oak Ridge National Laboratory
(865) 946-1226
gravesrl@ornl.gov

Kevin Stork
DOE Technology Manager
Department of Energy
(202) 586-2333
kevin.stork@ee.doe.gov

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U .S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.